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INFLUENCE OF INDEX PROPERTIES ON PREDICTION OF COMPACTION CHARACTERISTICS OF RED SOILS

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ABSTRACT

Compaction characteristics are the important parameter used to assess the indirect strength of component layers of the flexible pavement. Compaction characteristics control the strength of foundation layers of various soil structures. Laboratory compaction is the usual method in estimating the quality of soils used in civil engineering projects. Estimation of Compaction Characteristics from laboratory methods is time consuming and laborious. To assist the geotechnical engineers for quick assessment of compaction characteristics indirect methods like correlation models are useful. In this study 112 number of soil samples were tested for geotechnical characteristics like grain size distribution, gradation characteristics, consistency characteristics, and compaction characteristics. These were correlated and developed. Compaction models with R2 values.

KEYWORDS: Compaction Characteristics, Parameter & Correlation

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Original Article

1. INTRODUCTION

Economic development of any region depends on infrastructure projects related to civil engineering especially road networks, buildings, bridges, embankments, and earth dams etc. These structures required huge quantity of soils nearby site. The durability of the structure depends on the quality of material used on the specification followed. Compaction technique is one method to assess the strength and deformation w.r.to durability of the above structures which are made up of earthen materials. Estimation of these characteristics is essential in controlling the quality of a project these are direct and indirect methods for estimation of this characteristics to assist direct methods and to avoid delay of the construction time. Indirect methods are playing a wide role in estimating compaction characteristics such as OMC &MDD. Some of the thinkers contributed their research on developing the correlation between OMC and MDD as the dependent variable and index properties as independent variables are listed below.

- Omar (2003) developed prediction models to estimate the compaction characteristics of granular soils in the UAE. The prediction models are

  $\gamma_{dmax}(kg/m^3)=[4804574G-195.55\ W_L^{\,2}+156971(R\#4)^{0.5}-9527830]^{0.5}$

  $Log(W_O)=1.195x10^{-04}(W_L)^2-1.964G-6.617x10^{-03}(R\#4)+7.631$

- Sridharan &Nagaraj (2005) found that plastic limit can also give good estimates of compaction parameters.

  γ_{dmax} =0.23(93.3-W_p) OMC=0.92W_p

- Sivrikaya (2013) used two approaches named multiple linear regression analysis (MLR) and genetic expression program (GEP) to predict compaction characteristics of coarse-grained soils.

- Mujtaba (2013) proposed correlations for granular soils to estimate compaction characteristics using gradation parameters and compaction energy (CE).

  γ_{dmax}=4.49 log(C_u)+1.51 log(CE)+10.2

  Log(OMC)=1.67-0.193 log(C_u)-0.153 log(CE)

- Noor (2012) collected 106 samples of fine-grained soils from various Indian Hydropower projects to develop prediction models for the estimation of compaction parameters

  MDD=√PL-0.089LL+33.97/(PL+1.37)+19.05
  OMC=PI/G+3.424+0.462PL-G

2. MATERIALS AND RESULTS

To study the inter-relationship 112 red soil samples were collected from different regions of north coasted districts of AP and tests like grain size distribution (Dry and Wet analysis) (IS 2720 part 4), Plasticity characteristics (W_L, W_P, &I_P) compaction tests have been conducted and the results are as shown in table 1.

Table 1: Geotechnical Characteristics of Red Soils of Coarse-Grained Nature

S.NO	S	F	W_l	W_p	I_p	OMC	MDD
1	68	32	29	19	10	10.2	1.82
2	73	27	27	19	8	10	1.83
3	67	33	30	19	11	10.5	1.82
4	70	30	28	19	9	10.2	1.84
5	72	28	27	18.5	8.5	10	1.85
6	65	35	30	19	11	10.6	1.82
7	60	40	34	20	14	11	1.8
8	63	37	33	19	14	11	1.81
9	65	35	32	19	13	10.7	1.82
10	68	32	29	19	10	10.4	1.84
11	64	36	29	19	10	10	1.83
12	60	40	32	19	13	10.5	1.82
13	68	32	30	18	12	10.2	1.84
14	63	37	33	19	14	10.7	1.82
15	67	33	30	19	11	10.4	1.83
16	65	35	33	19	14	10.8	1.81
17	62	38	33	20	13	10.7	1.82
18	60	40	34	20	14	10.9	1.81
19	58	42	34	19	15	11	1.8
20	64	36	31	19	12	10.4	1.82
21	68	32	26	18	8	9.8	1.84
22	64	36	32	19	13	10.6	1.85
23	63	37	31	19	12	10.5	1.84
24	70	30	28	19	9	10	1.85
25	68	32	28	18	8	9.8	1.83
26	62	38	32	19	13	11	1.84
27	67	33	30	19	11	10.6	1.86

Table 1: Contd.,

28	60	40	33	20	13	11.2	1.83
29	65	35	30	19	11	10.5	1.85
30	70	30	28	19	9	10	1.86
31	72	28	27	18	9	9.8	1.87
32	66	34	32	10	12	11	1.84
33	63	37	34	20	14	11.5	1.82
34	70	30	30	20	10	10.6	1.84
35	73	27	29	19	10	10.4	1.85
36	69	31	27	18	9	10.2	1.86
37	62	38	30	20	10	10.7	1.84
38	73	27	29	19	10	10.3	1.85
39	67	33	29	19	9	10.5	1.84
40	68	32	30	20	10	10.7	1.84
41	60	40	34	20	14	11.3	1.83
42	66	34	32	20	12	10.8	1.85
43	73	27	28	19	9	10.3	1.84
44	68	32	28	19	9	10.4	1.83
45	68	32	32	19	13	12	1.86
46	56	44	34	20	14	12.5	1.84
47	60	40	32	20	12	12.2	1.85
48	72	28	28	19	9	11.2	1.88
49	65	35	30	19.5	10.5	11	1.88
50	78	22	26	18	8	10	1.9
51	80	20	25	18	7	9.8	1.9
52	62	38	33	20	13	12.2	1.83
53	75	25	27	19	8	10.8	1.88
54	70	30	25	18.5	6.5	9.3	1.85
55	72	28	24	18	6	9	1.84
56	66	34	25	19	6	9.5	1.85
57	69	31	25	19	6	9.2	1.86
58	74	26	23	18	5	9	1.84
59	68	32	26	19	7	9.8	1.83
60	65	35	25	18	7	9.4	1.84
61	68	32	25	19	6	9.6	1.85
62	70	30	24.5	18.5	6	9.4	1.84
63	76	24	24	18	6	8.8	1.86
64	80	20	23	18	5	8.5	1.83
65	73	27	24	18.5	5.5	9	1.84
66	78	22	23	18	5	8.4	1.8
67	72	28	24	18	6	9	1.88
68	70	30	25	19	6	9.2	1.86
69	74	26	24	18	6	8.8	1.86
70	70	30	25	18.5	6.5	9.3	1.87
71	68	32	25	19	6	9.5	1.88
72	75	25	24	18.5	5.5	9.2	1.86
73	66	34	25	18	7	9.5	1.85
74	67	33	25	19	6	9.6	1.84
75	63	37	25	19	6	9.3	1.86
76	72	28	24	18.5	5.5	9.2	1.84
77	77	23	23.5	18.5	5	9.4	1.86
78	70	30	25	18.5	6.5	9.2	1.85
79	67	33	25	19	6	9	1.84
80	72	28	23	18	5	9.3	1.86
81	67	31	24	18	6	9.1	1.84
82	69	31	25	18.5	5.5	9.3	1.84
83	65	35	25	19	6	9.6	1.83
84	73	27	23	18	5	9	1.84
85	76	24	23.5	18	5.5	9.2	1.85
86	74	26	23	18	5	9.1	1.84
87	78	22	23	18	5	9	1.84
88	66	34	25	19	6	9.4	1.85

Table 1: Contd.,							
89	69	31	24	18	6	9.3	1.84
90	78	22	22	18	4	8.8	1.78
91	82	18	22	18	4	8.5	1.77
92	75	25	23.5	18.5	4	9	1.79
93	74	26	23.5	18.5	4.5	8.8	1.78
94	78	22	22	18	4	8.4	1.77
95	82	18	21	18	3	8.2	1.76
96	86	14	21	18	3	8	1.77
97	74	26	22	18	4	8.7	1.77
98	83	17	22	18	4	8.6	1.78
99	85	15	21	17	4	8.4	1.76
100	83	17	21	17	4	8.5	1.78
101	78	22	22	18	4	8.7	1.79
102	76	24	22	18	4	8.9	1.77
103	68	32	22.5	18.5	4.5	9	1.76
104	70	30	23	18.5	4.5	9.1	1.78
105	76	24	22	18	3	8.8	1.88
106	84	16	21	18	3	8.5	1.85
107	82	18	21	17	4	8.4	1.85
108	78	22	22	18	4	8.6	1.86
109	80	20	21	NP	NP	9	1.86
110	87	13	NP	NP	NP	8	1.8
111	85	15	NP	NP	NP	8.6	1.84
112	88	12	NP	NP	NP	8	1.82

S= SAND (%), F= FINES (%), WL=LIQUID LIMIT, W_P= PLASTIC LIMIT I_P= PLASTICITY INDEX

OMC= OPTIMUM MOISTURE CONTENT MDD=MAXIMUM DRY DENSITY(g/cc)

D_{10}= SIZE OF SOIL PARTICLES AT 10% FINER, D_{60}= SIZE OF THE SOIL PARTICLES AT 60% FINER

C_U= COEFFICIENT OF UNIFORMITY

3. PARAMETRIC ANALYSIS OF RED SOILS

The following identifications are made from the test results of Red soils.

Increasing the percentage of sand particles increases the MDD values whereas increasing the fines particles decreases MDD values. Increasing a small percentage of fines increases MDD and OMC values. Increasing the percentage of fines increases the deformability conditions thereby increasing OMC values the shear strength and penetration resistance under condition. High densities and low OMC values are due to the occupation of more solids, availability of a wide range of particles and less plasticity characteristics. Domination of single size of particles decreases MDD and increases OMC values

4. CORRELATION

Based on the test results like grain size distribution i.e. (Gravel, Sand, Fine, particles), their range in terms of gradation coefficients such as coefficient of uniformity (C_u) and coefficient of curvature (Cc) and compaction characteristics various correlation relationships are established. It is further included plasticity characteristics in terms of Liquid Limit and plasticity index are correlated with compaction characteristics. Correlations models have generated by choosing OMC and MDD as dependent variable and gradation characteristics Plasticity characteristics as independent variables using excel Microsoft analysis. Simple linear regression analyses (SLRA), multiple linear regression analysis (MLRA) have been done and the following correlation equations are identified with R^2 values.

Table 2: Correlation Equations of Log Non-Linear Equations

S No	Variable	Log OMC Equations	R^2
1	f (LOG S, LOG F)	LOG OMC=-0.023 (LOG S) – 0.89 (LOG F) + 2.67	0.644
2	f(LOG S,LOG F,LOGI$_P$)	LOG OMC=-0.04(LOG S)-0.20(LOG F)+0.19(LOG I$_P$)+1.26	0.86
3	f (LOG S,LOG F, LOG D$_{60}$)	LOG OMC=- 0.022 (LOG S) – 0.53 (LOG F) – 0.26 (LOG D$_{60}$) +1.90	0.65
4	f (LOG S,LOG F,LOG D$_{60}$,LOG I$_P$)	LOG OMC=- 0.04(LOG S) – 0.18 (LOG F) – 0. 017 (LOG D$_{60}$) + 0.18 (LOG I$_P$) +1.22	0.868
5	f (LOG S, LOG F,LOG D$_{60}$, LOG C$_U$, LOG I$_P$)	LOG OMC=- 0.041 (LOG S) – 0.18 (LOG F) – 0.020 (LOG D$_{60}$) – 0.002 (LOG C$_U$) +0.19 (LOG I$_P$) + 1.22	0.869
6	f(LOGS,LOGF,LOGD$_{60}$,LOG C$_U$,LOG W$_L$,LOG I$_P$)	LOG OMC=0.072 (LOG S) + 0.21 (LOG F) – 0.029 (LOG D$_{60}$) – 0.0008 (LOG C$_U$)+ 0.623 (LOG W$_L$) + 0.005 (LOG I$_P$) – 0.420	0.89
		LOG MDD EQUATIONS	
1	f (LOG S, LOG F)	LOG MDD=0.09 (LOG S) + 0.21 (LOG F) – 0.26	0.13
2	f(LOG S,LOG F,LOG I$_P$)	LOG MDD=0.137(LOG S)+0.37(LOG F)+0.0613(LOG I$_P$)-0.64	0.22
3	f (LOG S,LOG F,LOG D$_{60}$)	LOG MDD=0.090(LOG S) – +0.311 (LOG F) – 0.07 (LOG D$_{60}$) – 0.47	0.16
4	f (LOG S,LOG F,LOG D$_{60}$, LOG I$_P$)	LOG MDD=0.13(LOG S) + 0.446 (LOG F) – 0.06 (LOG D$_{60}$) + 0.011 (LOG I$_P$) – 0.79	0.24
5	f(LOG S,LOG F,LOG D$_{60}$, LOG C$_U$,LOG I$_P$)	LOG MDD=0.137(LOG S) + 0.44 (LOG F) – 0.060 (LOG D$_{60}$) – 0.0002 (LOG C$_U$) + 0.011 (LOG I$_P$) – 0.7977	0.24
6	f(LOG S,LOG F,LOG D$_{60}$, LOG C$_U$,LOG W$_L$,LOG I$_P$)	LOG MDD=0.116 (LOG S) + 0.37 (LOG F) – 0.059 (LOG D$_{60}$) + 1.88(LOG C$_U$) – 0.115 (LOG W$_L$) + 0.046 (LOG I$_P$) – 0.493	0.277

The strength, effectiveness of these correlations can be represented by their R^2 values by performing multiple regression analysis. From the correlation, it is identified that grain size distribution (S, F) has considerable influence on OMC values with R^2values as 0.644 whereas grain size distribution with gradation parameters (C_u) which representing a range of particles further improved correlation coefficient (R^2) to 0.89.

It is also noted that the inclusion of the plasticity index with grain size distribution and gradation characteristics of the rose correlation coefficient (R^2) to 0.86. The inclusion of plasticity characteristics (I_p) has a high influence on OMC characteristics. The inclusion of more number of effective parameters of improves the prediction of OMC values with a high correlation coefficient. It is further identified that the involvement of more than one variable in the correlation analysis (Regression analysis) made more accurate in the prediction of log OMC values. In the present study the predictive equations are simple and can be effectively used for the prediction of log OMC values of Red soils are with high accuracy.

In case of MDD models very small values of R^2 in the range of 0.13 to 0.277 with grain size distribution and the inclusion of gradation parameters and plasticity index values. The lowest R^2 values are due to a narrow range of MDD values for all the soils under study has been reported.

5. CONCLUSIONS

- Soil with a wide range of particles with a low percentage of fines exhibited high dry densities and increasing the percentage of fines increases OMC values.
- The other models developed by MLRA for correlating OMC and MDD value with gradation characteristics (S,F,D60,Cu) have shown relatively with high R2 values
- The statistically better performance can be obtained from the model developed using multiple Non-linear regression analysis (MNLRA) by the inclusion of plasticity characteristics showing the highest R2 value and further inclusion of Nonlinear analysis improved correlation relationship effectively with high R2 values 0.89

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